FOSTER WHEELER DEVELOPMENT CORPORATION

# Second Generation PFBC Systems R & D
Contract DE-AC21-86MC21023—79

Monthly Report Period Ending March 2000

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## TECHNICAL PROGRESS REPORT NUMBER 21023R56
## FOR MONTH 144 (MARCH 2000) -- PHASE 2

No work was performed; the two remaining Multi Annular Swirl Burner test campaigns are on hold pending selection of a new test facility (replacement for the shut down UTSI burner test facility) and identification of associated testing costs.

**TECHNICAL PROGRESS REPORT NUMBER 21023R57**
**FOR MONTH 113 (MARCH 2000) -- PHASE 3**

## Commercial Plant Design Update

### Introduction

The Second-Generation PFB Combustion Plant conceptual design prepared in 1987 is being updated to reflect the benefit of pilot plant test data and the latest advances in gas turbine technology. The updated plant is being designed to operate with 95 percent sulfur capture and a single Siemens Westinghouse (SW) 501G gas turbine. Using carbonizer and gas turbine data generated by Foster Wheeler (FW) and SW respectively, Parsons Energy and Chemicals Group prepared preliminary plant heat and material balances based on carbonizer operating temperatures of 1700 and 1800EF and found the former to yield the higher plant efficiency.

As a result, 1700EF has been selected as the preferred operating condition for the carbonizer. A first cut plant heat and material balance predicts a 47.7% plant efficiency (HHV) with a net power output of 421.1 MWe. The latter includes a plant auxiliary load estimated to be 23.5 MWe or 5.26% of the gross plant power and a transformer loss of 1.5 MWe. Coal drying is through natural gas combustion, and the thermal energy input of the natural gas has also been included in the heat rate calculation. In the proposed plant, evaporation and primary steam superheating tube surfaces are placed in both the pressurized circulating fluidized bed boiler (PCFB) and the gas turbine heat recovery steam generator (HRSG). The superheated steam from these units is mixed and then heated to 1050EF in the PCFB finishing superheater. With regard to steam reheating, the primary stage is located at the front of the HRSG and the final stage is located in the PCFB.

The steam water circulating arrangement proposed for subject plant (see Fig. 1) utilizes three boilers operating in parallel, i.e., a PCFB boiler, a gas turbine heat recovery boiler, and a hot air boiler, the latter being used to help cool the 811F gas turbine compressor discharge air before it enters a boost compressor. The three-boiler arrangement is the result of minimizing the plant feed water flow rate. By doing so, the steam turbine size can be minimized yielding a high gas turbine to steam turbine power ratio and thereby maximizing the plant efficiency. Although the three-boiler arrangement maximizes efficiency, it was felt the incremental gain may not be worth the added operating complexity and cost of having to match and blend steam from three different boilers. By increasing the boiler feed water (BFW) flow rate, the total amount of heat that can be absorbed by the steam cycle prior to the start of evaporation can be increased, and hence the number of boilers reduced.

### Work Performed in March

Parsons reviewed the two and single boiler circuitry arrangements suggested by FW (see Fig. 2 and 3), and after making refinements ran several new heat balances. Each of the alternate configurations included provision for low pressure feed water heaters and zero reheat in the HRSG. These configurations were then modified to include either total or partial PCFB air bypass. The purpose of the air bypass was to maximize heat rejection to the bottoming cycle for a given plant coal flow. The energy savings due to a decrease in the main “boost” compressor auxiliary power load combined with the increase in steam turbine power output was greater than the thermal input increase required to overcome the cooling effect of the bypassed air on the combustion turbine firing temperature. As a result, greater system efficiency was achieved.

The estimated performance of the two arrangements were:

| | Two Boilers | Single Boiler |
|---|---|---|
| Gross Power, MWe | | |
| Gas Turbine | 239.25 | 239.25 |
| Steam Turbine | 267.46 | 299.30 |
| Total | 506.71 | 538.55 |
| Auxiliary Power, MWe | 24.89 | 26.20 |
| Net Power, MWe | 481.82 | 512.35 |
| Plant HHV Efficiency, % | 47.5 | 47.0 |
| Plant HHV Heat Rate, Btu/kwhr | 7184 | 7251 |

The above results were discussed with the DOE, and it was decided to proceed with the less complex two-boiler plant arrangement.

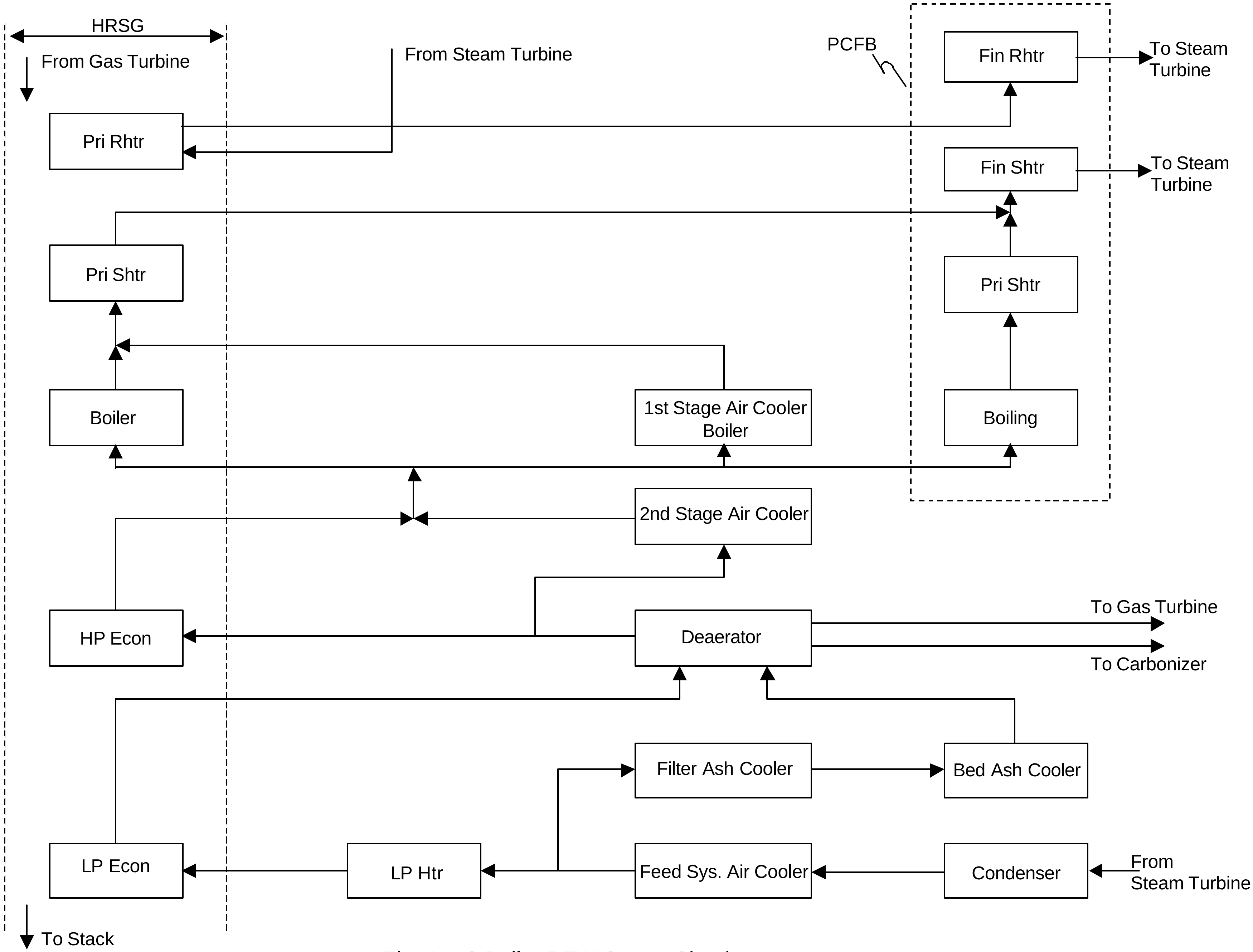


Fig. 1 -- 3 Boiler BFW-Steam Circuitry Arrangement

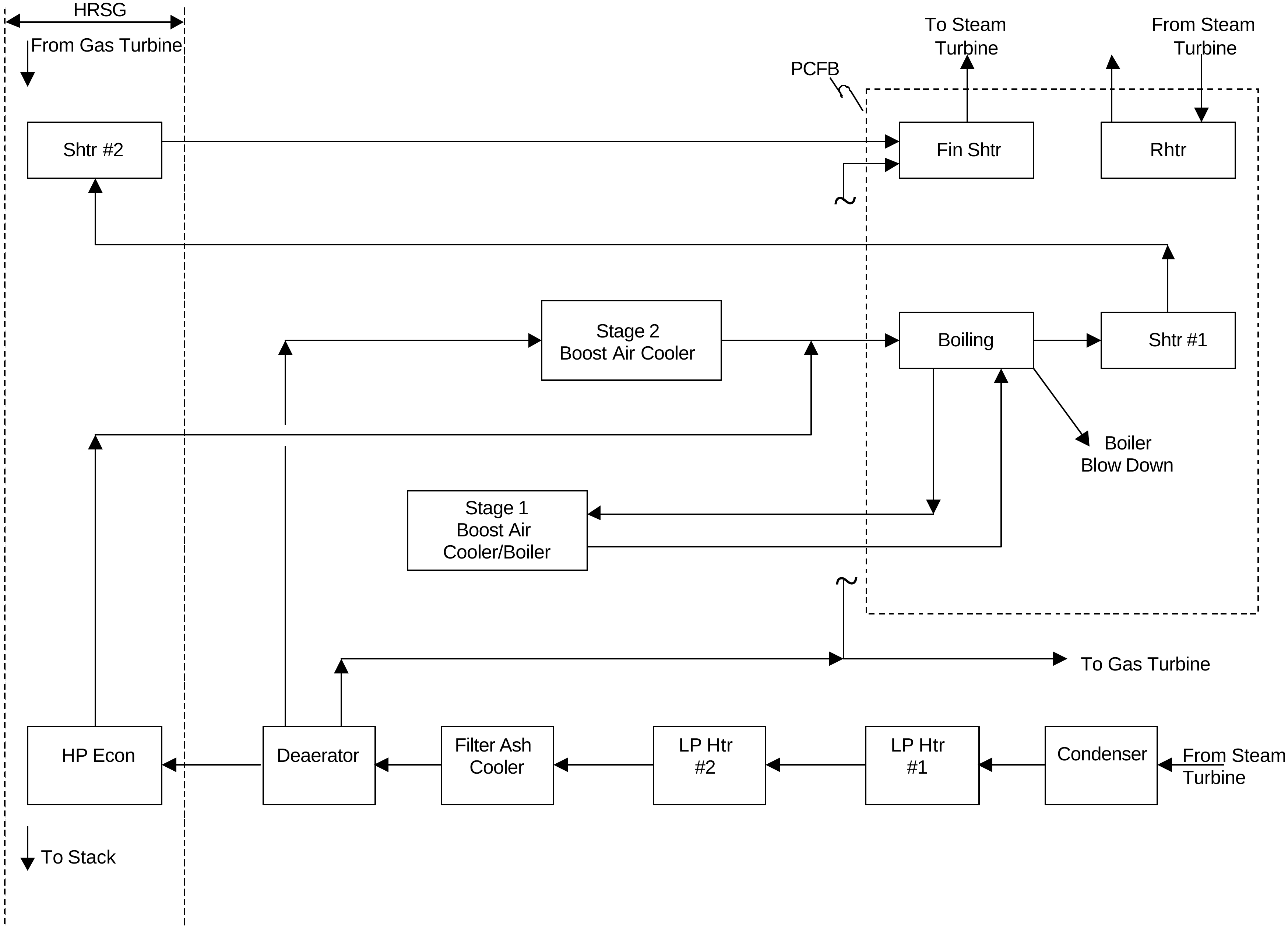


Fig. 2 -- 2 Boiler BFW-Steam Circuitry Arrangement

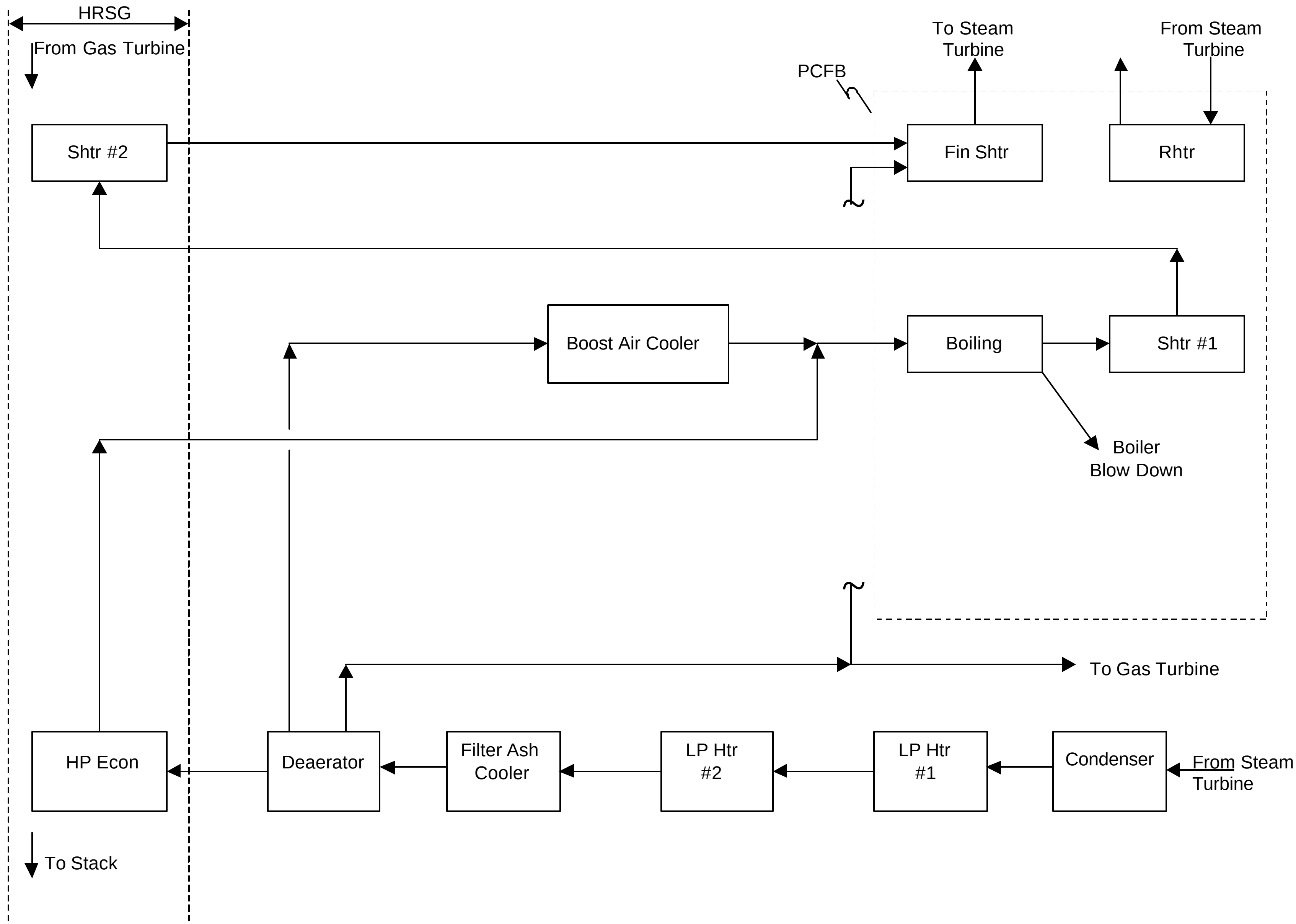


Fig. 3 -- Single Boiler BFW-Steam Circuitry Arrangement